CORRESPONDENCE:

Policy institutions and forest carbon

To the Editor — Macintosh *et al.*[1] claim to apply a life-cycle assessment (LCA) approach to evaluate the greenhouse gas (GHG) emissions impacts of alternative forest management options. Although we agree with their basic assertion that policy impacts should be considered in such analyses, we identify three issues with their methods and interpretation. Consequently, they fail to quantify the likely GHG emissions impacts of the alternatives compared, and their conclusion overlooks the deficiencies in current policies that are revealed in their results.

As defined by the International Standards Organization[2–3], LCA aims to examine the full impacts of a process or product, and therefore includes upstream and downstream impacts so that the shifting of burdens between life-cycle stages, impacts and regions of the world do not go unnoticed. In contrast, Macintosh *et al.*[1] apply a constrained model in their 'basic' and 'national' scenarios, excluding those parts of the life cycle that occur abroad, in order to align with a nation's GHG emissions obligations. They claim to apply LCA terminology to policy institutions, defining three categories: macro, attributional and consequential. However, only the latter two terms align with recognized LCA methods. The effects of policies can be modelled attributionally[4] or consequentially[5], but it is not clear to us which approach the authors used, or a mixture thereof. Macintosh *et al.*[1] present 16 scenarios, applying different system boundaries across three different accounting approaches comprising permutations with or without harvest, and with or without bioenergy. It is not clear how these relate to macro, attributional or consequential policy institutions. Furthermore, we find the distinction between consequential and attributional policy institutions unclear. Macintosh *et al.*[1] define attributional policy institutions as the rules and procedures used to assign responsibility for GHG emissions between actors, whereas consequential policy institutions are those intended to effect behavioural change. They classify GHG accounting rules as attributional, however, these rules are intended to influence behaviour in order to achieve policy objectives[6,7]. Thus, we consider that the methods used do not constitute LCA, and that their application of LCA terminology to classify policy institutions is inaccurate and potentially confusing.

Macintosh *et al.*[1] do not use an analytical approach such as economic modelling[5] to analyse the effects of policy institutions on Australia's emissions. Rather, they assume these effects. They assume that caps on emissions create a floor and ceiling, so that, whatever the change in the system being modelled, there will be no net effect on emissions. Similarly, they assume that the existence of a renewable energy target means that bioenergy will displace other renewables and not reduce net emissions, as gains from product and fuel substitution are counterbalanced by assumed emission increases in other sectors. We note that any renewable option could be disregarded as non-beneficial with this approach.

Under these constrained assumptions, Macintosh *et al.*[1] show that ceasing harvest in the study region would have very little impact on global GHG emissions. However, their results reveal that the current GHG accounting methods calculate an apparent substantial climate benefit from cessation of native forest harvest, when in fact there may be none. Thus, Australia could earn substantial credit for ceasing native forest harvest despite the lack of true emissions reductions. Such credits would allow other sectors to increase emissions, making it easier for Australia to reach its target without implementing the society-wide systems transformation that is needed to meet longer-term climate stabilization targets. The authors did not comment on these perverse outcomes.

Macintosh *et al.*[1] illustrate that alternative accounting systems significantly affect the apparent climatic impacts of forest management options. Indeed, the value of their paper is that it shows the sensitivity of results to the choice of system boundary and modelling assumptions. The obvious conclusion to be drawn from their study is that current GHG accounting approaches need revision. We suggest that such revisions should be guided by comprehensive assessments that include full life-cycle emissions, compare equivalent scenarios and reflect market dynamics, in order to analyse the potential impacts of policy institutions. ❐

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Reply to 'Policy institutions and forest carbon'

Macintosh *et al.* reply — Cowie *et al.* make a number of claims about our analysis, all of which we believe to be misguided. For example, they claim our 'basic scenarios' excluded "those parts of the life cycle that occur abroad," even though our article explicitly states otherwise. They also claim it is unclear whether we applied an attributional or consequential approach to life-cycle assessment (LCA), despite the opening paragraph clearly stating that the article is concerned with consequential LCA (CLCA).

Their final critique is that we did not comment on deficiencies in greenhouse gas accounting rules that were exposed by our analysis. This would be a fair point if the object of the article was to explore the strengths and weakness of relevant accounting frameworks. However, it was not — it was to illustrate the relevance of the different types of policy institutions to forest-related LCA.

The real issue of substance in their Correspondence is the assertion that our analysis is deficient because we assume the effects of policy institutions on emissions rather than empirically analysing them. The point of difference is best illustrated with a hypothetical case involving a cessation of forest harvesting, which displaces production to a sector covered by a capped emissions trading scheme (ETS).

Our position is that, in a CLCA concerned only with net emission outcomes, it is sufficient to assume the ETS functions as intended, meaning the change in forest management should have no effect on the net emissions under the scheme. After harvesting stops, and production and emissions in the capped sector increase, the operation of the ETS should ensure the emission increase is fully offset by reductions elsewhere. Cowie *et al.* argue this is wrong because the effects on emissions should be based on empirical analysis.

The difference in perspectives is, in our view, a product of different method preferences. Cowie *et al.* favour attributional life-cycle assessment (ALCA), which assigns emissions to relevant products and systems using data on average physical flows of materials and energy[1–7]. Because ALCA is backward looking — as it provides a historical estimate of average emissions from a process or technology — it is inappropriate to assume effects without empirical evidence. An ALCA on our hypothetical case would also exclude the effects of the ETS because the focus would be on how to apportion emissions to the wood and non-wood production systems.

We believe CLCAs are preferable for public policy-making[8–10]. In CLCA, the objective is to assess how emissions are likely to change in response to a decision; here, the change in emissions triggered by the change in forest management practices[1,3,8–12].

CLCA's future orientation means that assumptions must be made about a number of variables, including policy institutions. Historical data are relevant only to the extent that they provide a reasonable basis for projecting the change in emissions from the relevant management decision.

Consistent with this, a CLCA on the hypothetical change in forest management would have to consider the ETS because it is designed to shape emissions outcomes by changing incentives at the margin[1,8,9]. It should ensure that the increase in emissions within the boundaries of the scheme are fully offset. When Cowie *et al.* say that, according to our approach, "any renewable option could be disregarded as non-beneficial," they allude to this point. Only, it is not that the alternative renewable options are 'non-beneficial', it is that the policy institution is the driver of the emission outcome.

Of course, alternative assumptions could plausibly be made about the effects of the ETS but they would still be assumptions. Cowie and colleagues' argument that it is inappropriate to simply assume the effects of policy institutions in a CLCA is the equivalent of telling an economic forecaster they cannot make assumptions about how economic policy might change in the future. An inevitable aspect of all activities involving forward-looking projections is that assumptions must be made about what the future holds. ❐

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COMMENTARY:

El Niño and a record CO_2 rise

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The recent El Niño event has elevated the rise in CO_2 concentration this year. Here, using emissions, sea surface temperature data and a climate model, we forecast that the CO_2 concentration at Mauna Loa will for the first time remain above 400 ppm all year, and hence for our lifetimes.

The long-term rise in atmospheric CO_2 concentration, approximately 2.1 ppm yr^{-1} over the past decade, is caused by anthropogenic emissions arising from fossil fuel burning, deforestation and cement production[1,2]. The annual growth rate, however, varies considerably as a result of climate variability affecting the relative strength of land and ocean carbon sources and sinks. The annual growth rate measured at Mauna Loa, Hawaii[3,4] is correlated with the El Niño–Southern Oscillation (ENSO), with more rapid growth associated with El Niño events[5–9] through drying of tropical land regions and forest fires. To test the predictive value of this relationship, we present a forecast, made in October 2015, of the CO_2